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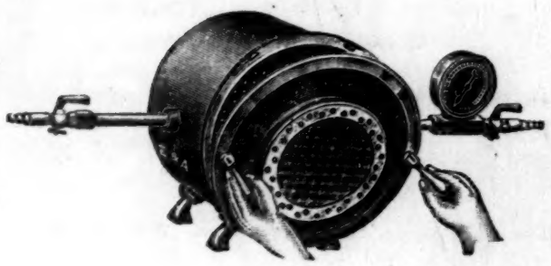

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SCIENCE

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THE STORY OF COSMOLOGICAL THEORY[1]

I

IT may be that primitive man felt none of the

> Blank misgivings of a creature
> Moving about in worlds not realized.

For him, perhaps it was enough to taste the joy of living, to watch the rising and the setting of the sun, to gaze upon the mountain, the river and the restless sea, and never to ask himself the question "what is this world in which I live, and how did it come into being?" But this problem eventually presented itself, for there has been implanted within the human breast that which distinguishes its possessor from the beasts which perish, the passion for knowledge, the deep longing for

> Authentic tidings of invisible things,
> Of ebb and flow and ever-during power:
> And central peace subsisting at the heart
> Of endless agitation.

And so there arose those questions about himself, about the visible universe in which he dwelt, and that invisible world about which he dreamed, from which have sprung all that we now call science and philosophy.

How slow and laborious have been the steps by which knowledge has been attained, and how childish and even grotesque the answers to these first questionings. But to have any theory at all for the first causes of things is very much better than to have none, and these crude products of primitive man, and the refined deductions of the modern scientist are the same at

[1] Opening lecture of the year, delivered at the Autumn Convocation, McMaster University, Toronto.

heart. Alike they seek to deduce from known facts the underlying principles of nature. If the modern hypothesis appears to lie much nearer to the truth, it is because the facts upon which it is based are more numerous and more completely verified. Nor should we forget that it has had the advantage of a long series of tentative explanations, which it now replaces. All our advances have been made over the remains of discarded theories.

It is here proposed to trace in outline the history of the theories which from time to time have been suggested to account for the way in which the earth was formed. It will be seen that we have here three stages in human intellectual development. In the first the world was conceived to be due to the literal handicraft of a beast, a demigod or a divinity. In the second it was realized that a nobler origin must be sought, but methods of scientific criticism had not been perfected sufficiently to put the theories to the test. In the third, every one had to be submitted to the most rigid dynamical analysis.

II

In order that these primitive theories may have an unprejudiced hearing it is well for us to try and put ourselves in the place of their authors. Let us view the world as seen through the eyes of the ancients.

At the time of the dawn of consciousness, man found himself on what appeared to be a flat and circular earth. As he extended his wanderings this way and that, although great ranges of mountains occasionally stood in his way, they could eventually be crossed, but sooner or later he seemed always to come to the shores of the impassable sea. So he concluded that the disc-shaped land was completely surrounded by the ocean, which flowed like a mighty river around the earth. Above him was a great dome, forming a lid to it all. This was evidently of solid material, glass or some metal, possibly brass. Some claimed that it must be transparent, others, that it was perforated by windows, for at night the light of the celestial regions shone through, and he called these bright objects stars. The Egyptians had a slightly different explanation, for, according to them, the stars were lamps hanging down from the ceiling of the world on the end of chains. Over this dome he saw passing, with wonderful regularity, various bright objects, notably the sun, and he soon observed, in addition to its regularity, that it had a very rapid motion, for it came up from beyond the River Oceanus, probably through a great door, in the morning, and in about twelve hours had crossed the dome of the heavens and was at the door of the evening, ready for its return journey through the upper world down to the gate of the morning once more. This rapid journey, in the days before steam or gasoline, could be explained only by the use of swift animals, and what animals are so swift as horses.

Above the dome of the heavens there seemed to be another ocean, for ever and again the roof leaked and showers of rain fell upon the earth. It was evident also that there must be beings there who controlled the activities of nature, and probably they could occasionally climb down by way of the sides of high mountains, whose tops, inaccessible to man, undoubtedly touched the sky, and indeed, probably helped to support it.

Now all the mysterious and terrifying forces of nature were to be explained in a perfectly naturalistic way, by the intervention of these beings from the upper world. Was the oak under which our forefather had taken refuge in a storm, shattered by the lightning, it was because one of the gods had hurled a flaming dart.

Was he unfortunate enough to receive into his veins the poison of malaria, it was because an evil spirit had entered into him and had to be induced to come out by a bribe, or driven out by the use of mystic combinations of words which were calculated to cast a spell over it. So when the author of creation was thought of it was in the form of an animal like those he hunted, but much bigger. A turtle, swimming in the primeval ocean, dives down, as he had often seen it, and, coming up, bears upon its back some of the mud from the bottom, and on this, trees grow and living creatures move and among them all, himself. At times the load grows heavy, and the turtle moves, and the earth quakes, and perhaps some day the whole will slip again beneath the waves.

Or, again, a number of animals have escaped the destruction of a previous earth on a raft. They float for many days upon the face of the waters and find no place for the soles of their feet to rest. They take turns at diving in order to bring up some earth from the bottom, but it is not until several of them had essayed the task that a grain of sand is recovered. From this they mold the new earth, and then disembark and a new era commences.

These simple theriomorphic tales are found among the less advanced races. In the minds of those who had observed more carefully, and thought more deeply, profounder ideas began to prevail. To the thinker of Neolithic times, as indeed to him of to-day, one of the most wonderful things in nature is an egg. Within this thing, apparently so simple in its constitution, there is developed, and that in the course of a very short time, all the complexity of structure of reptile or bird. Perhaps even he dimly realized that all things living proceed from an egg. It was evident also that the order of nature is from the simple to the complex, and the world, in its marvelous complexity, is no doubt, he thought, a living thing. What would be more natural, then, than that the world itself is the final product of the development of an egg? This theory is found again and again in the mythologies of ancient races, persisting even among the stories of a nobler cosmogony. Thus in the Book of Manu, in Indian Classics, we read "the self-existing lord, with a thought, created the waters, and deposited in them a seed which became a golden egg, in which egg he himself is born as Brahma, the progenitor of the world."

III

We have now come to the stage in human development when it was no longer necessary to explain the origin of the world in terms of beasts or demigods. A new theory now had to be formulated in the light of increased knowledge and broader mental grasp. To some it may have appeared that things had always existed as they are, but the philosophical necessity for an explanation of origins early impressed itself upon the minds of the Greeks, who were the first to devote themselves to such speculations.

Two alternatives formed the foundations for the theories of two opposing schools of thought, the one of monism, the other of dualism. To Leucippus and Democritus and their disciples the world appeared to have been the result of a fortuitous concourse of atoms. Behind it all they saw no plan, no intelligence. This was the underlying concept of the great poem "De Rerum Natura" of the Latin poet Lucretius, who lived in the first century B.C. He tells us:

> Nam certe neque concilio primordia rerum
> ordine se suo quaeque sagaci mente locarunt
> (5: 419),

which may be translated:

For verily not by design did the first-

beginnings of things station themselves each in its right place by keen intelligence.

To Plato and his school, on the other hand, the orderly course of nature can be explained only as the incarnation of a divine plan. So he conceived of the universe before the creation as consisting, on the one hand, of chaos and disorder, matter without plan or qualities; on the other hand, of the eternal plan or soul of the world existing in the mind of God. Then the creator, taking this inert nothingness, impressed upon it the eternal idea and the whole becomes an organic unity.

Thus the universe was created, unchanging, unchangeable, and this idea, as modified by Aristotle, became the current coin of the intellectual world. Nearly twenty centuries passed before the next advance came with the realization that the world did not spring into existence full grown, but that its present state is the result of a long series of changes.

IV

Before this idea of progressive development could be attained, it was necessary that certain hoary fallacies should be cast aside and correct notions substituted. Until it was realized that the earth and the other celestial bodies are spheres, and that the sun, and not the earth is the center of our own system, the progress of astronomy and cosmology were slow and imperfect. But these were concepts of very gradual growth.

In the early part of the fifth century B.C., Parmenides, of Elea, wrote a short poem on Nature, of which we still possess a few fragments. In this he refers to the spherical form of the earth, a truth which he appears to have been the first of all mankind to enunciate. Around the earth as a center he conceived a series of concentric spheres on which were fixed the heavenly bodies, an idea which was not without its supporters during the following two thousand years. A little later it seems to have been taught by Pythagoras. From it his disciples and successors framed their interesting theory of the Cosmos, which was believed to consist of the "central fire," the "hearth of the universe," round which were ten concentric spheres. There must be ten, for the system is perfect, and according to their idea, ten is the number of perfection. These spheres bear in succession the fixed stars, the five planets, the sun, the moon, the earth and another celestial body, which they called the "antichthon" and which served as a screen between the earth and the central fire. Around this blazing pivot revolved the earth once in 24 hours, always facing outwards, and so bringing into view the various parts of the heavens in succession. Consequently the back of the earth must always be dark. Therefore, if one were to travel past India, there he would find a land of perpetual twilight, where neither the blessed light of the sun nor the rays from the central fire could ever penetrate.

The spherical form of the earth was subsequently taught by Plato, who, like all that followed for two thousand years, placed it in the center of the universe, and finally, by Aristotle, who became, until the Renaissance, the dominating figure in European thought.

But the development of correct cosmological ideas was not destined to continue uninterruptedly. In 389 the great library of Alexandria was destroyed. Shortly after came the fall of the Western Empire and the long, dark night of the middle ages set in. Most of the gains which science had made during the previous centuries were forgotten, and the Church, which then became the custodian of all that was thought worthy of preservation, set its face firmly

against the learning of the pagan Greeks. A new theory of the universe, according to a plan which would follow their interpretation of the Holy Scriptures, consequently appeared to be a desideratum. The great task of inventing this fell to Cosmas, surnamed, on account of his extensive travels, Indicopleustes, the Indian voyager. According to him, since the Epistle to the Hebrews expressly declares that the inner tabernacle was a pattern of the Kingdom of Heaven, it follows that, if we would understand the construction of the universe, we can find it epitomized in the description of its antetype in the Book of Exodus. The table of shewbread with its wavy border represents the earth surrounded by the ocean. Therefore the earth is rectangular, twice as long as it is broad, its longer dimension extending east and west. Beyond the ocean, as is clearly proved by the existence of an outer border to the table, lies another land where is situated the earthly paradise. That other was the home of mankind until the flood, and then Noah sailed across. But since that day the return journey has become impossible, owing to the tempestuous weather which ever prevails upon the ocean. We who actually live in trans-oceanic lands may be permitted to disagree on some points with the learned theologian, for we have found neither the terrestrial paradise nor the tree of life which it contained. At the edges of this other earth were erected the walls of heaven topped by a roof shaped like half a cylinder. But it is a two-storied building, is the universe, and the firmament forms the division which is at once the roof of the world and the floor of heaven. Above the firmament are the abodes of the blest.

The motions of the heavenly bodies are to be explained by the activities of the angels. They carry the stars in orderly succession over the heavens. They also carry the sun. Now the northern part of the earth is very high, in fact rising to an exceeding lofty mountain, and on their return journeys the sun by night and the stars and moon by day are borne by the angelic host behind the mountain and so are not seen. In winter they go with the sun near the base, and night is long; in summer near the top and night is short.

This famous system of Cosmas, the crowning absurdity of medieval science, the culminating flower from seeds of wilful ignorance, was indeed the climax of the anti-scientific spirit. After this the old ideas of the constitution of the universe once more began to be critically studied, and once more the wheels of progress, for many centuries almost stationary, began to move.

For the first hypothesis of a universe which revolves around the sun, we must go back many ages. In the third century before Christ, Aristarchus of Samos first conceived this great truth. How he arrived at this he has left us no explanation. A century later a Babylonian named Seleukis reaffirmed the diurnal motion of the earth, but for the most part, for 1,700 years, the voice of Aristarchus was as of one crying in the wilderness.

Then came Copernicus, one of the world's great geniuses. In the work of his predecessors one must search diligently to find the grain of truth among much chaff, but with him the system of the universe was revealed with great clearness. This, substantiated by the work of Kepler, of Galileo and of Newton, has formed the basis of all subsequent progress.

V

When once the nature of the sun had begun to be understood, and the stars were seen to be, like it, fiery orbs, it was natural that men should begin to think that the earth itself, now seemingly cold, might

have been a fiery mass. This idea was first suggested by Descartes in his "Principia Philosophiæ," published in 1644. According to him, the earth, like every other celestial body, was formed by the aggregation of primitive particles of matter which have an inherent whirling motion. The resultant sphere, after it has changed from the gaseous to the molten condition, cools and becomes covered by a solid crust. But the central portion still retains its hot and plastic condition, which is manifested by the phenomena of mountain-building and vulcanism.

Leibnitz, thirty-six years after, in his "Protogœa," which, however, was not published until after his death, followed an almost identical hypothesis, conceiving the earth to have been built up of an aggregation of whirling ultimate elements or "monads" of matter. But while Descartes looked upon the motion as being due to the momentum supposed to be present in constant amount in the universe, Leibnitz believed it to be due to the force which accompanied the separation of light from darkness.

Later this doctrine was carried a step farther by the philosopher Kant, and finally by Laplace in his theory so modestly put forward, which has since become so famous under the name of "the Nebular Hypothesis."

Briefly stated this hypothesis predicates the origin of our solar system in a great fiery mass of incandescent vapor, similar to the nebulæ, which are among the most wonderful objects revealed to us by the telescope. The parent nebula of our system must have extended far past the present orbit of the outermost planet, Neptune, then undiscovered. In order to fill this space the matter available must have been spread out extraordinarily thin; in fact, the density would be one millionth of that of the air we breathe. The whole was subject to a rotary motion. As time passed, heat was radiated into space, and, as the tenuity was maintained by heat, the mass became cooler and denser. Particles on the circumference would thus steadily move closer in to the center. Now the velocity of any such particle would remain unchanged, while the distance it would have to travel in order to complete the journey around the center, would steadily grow less. It follows that it would be whirling around the axis at an ever-increasing rate, and consequently, with an ever-increasing tendency to fly off into space. At the same time the pull of gravity, since the particle is closer to the center, is constantly growing greater. It is then subject to two steadily increasing forces, one of which tends to throw it off, the other to drag it down. A time will come when these two forces will just balance and the particle will go up neither nor down, but remain revolving in an orbit. The total result of this on all the particles of the outer zone would be to leave them in the form of a ring of gas. Similarly, the same process would be followed in the case of another zone, until the whole would resolve itself into a central spherical nebula surrounded by a series of rings. Each ring in turn would soon break, and the gas of which it was composed would come together in a revolving sphere, which might give rise to other rings. The system is constantly cooling, and the spheres of gas, finally solidifying, give rise to the planets and satellites.

The simplicity and grandeur of this theory fire the imagination. It is no wonder that it took firm root. For several generations it was received without reservation. Gradually, however, serious defects began to be seen. For instance, if we calculate the rate of motion of the molecules of such a system, the temperature and rate of rotation of the whole being

known, it can be proved that this motion would be so great that the force of gravity, even of so great a mass, could not prevent them from flying off into space and so being lost.

Again, it can be calculated from the facts at our disposal, where the rings would be left by such a cooling nebula. It is then found that the first ring, instead of being in the position of the present orbit of Neptune, would be inside the orbit of the inmost planet, Mercury. Where fact and theory do not agree, so much the worse for theory.

These are typical of the numerous and insuperable objections to the acceptance of the hypothesis. Within the last few years, the belief has been gaining ground among astronomers and geologists that this theory, so long the accepted one, must in its turn be discarded.

The cogency of the difficulties which have presented themselves whenever the theory of Laplace has been critically studied cleared the way for the meteoritic theory as presented by Lockyer and modified by Darwin. But here again the objections raised are so many and so reasonable that it stands on no surer a foundation than its predecessor.

Of recent years, the Planetesimal Theory of Chamberlin has been gaining ever-increasing support. Like the authors of preceding theories, he scanned the heavens for facts which might have a bearing upon the problem in hand. He saw, like them, the brilliant masses of "star dust" which we call nebulæ, but he saw also the importance of the fact that there are two distinct kinds of nebulæ. One kind, sometimes spherical, sometimes irregular in shape, is composed of incandescent gas; the other, consisting of two tightly coiled spiral arms, is evidently made up of solid particles. In the latter only do we find indications of the important metallic elements which occur in the earth.

This suggested to him that the parent nebula of our solar system was probably one of the spiral type, and his first problem was to account for the origin of such a nebula. An occurrence, famous in the history of astronomy, has an important bearing upon this.[1] Nearly 350 years ago (November, 1572), Tycho Brahe, the famous Danish astronomer, was very much astonished to observe a new star in the constellation Cassiopeia. An hour before he had scanned that part of the heavens and saw nothing, and when he looked again there it stood, a star of the first magnitude. From night to night it grew in magnificence, surpassing in turn the fixed stars, the planets, even Venus at her brightest, until it could be seen at noonday. It had now become the most glorious and brilliant orb in the heavens, giving, it has been calculated, 100,000 times as much light as our sun. Then this strange luminary slowly faded away, nightly becoming less brilliant, until, after the lapse of 17 months, it sank into final darkness.

How is this astonishing phenomenon to be explained? The general belief is that it was probably due to the collision of two great celestial bodies. Their energy of motion was changed into molecular energy, and the elements melted with fervent heat. So hot indeed did they become, that a great cloud of incandescent gas was the result, whose molecules were moving at such rapid rates that they were whirled away into space and so disappeared. Other stars of this kind have frequently been observed since then, but never has one so brilliant been recorded.

Now it may be that we have here a typical example of the formation of a gaseous nebula, though but a temporary one. Had the impact been less violent it might have been permanent. But what

would have been the result if the bodies in question had not actually collided, but had passed very close to one another? It can be demonstrated mathematically that such an approach would entail the formation of two prominences, on each body one at the point of least distance apart, and one diametrically opposite. If the approach be close enough, these prominences may be drawn out into the form of two long arms composed of discrete particles. As these bodies pass, each, by the pull of its gravity, will communicate to the other a rotatory motion which will result in the coiling of the arms. These will be composed of large numbers of comparatively small particles, each of which is revolving in a regular orbit around the central nucleus of the system. These particles, resembling in their constitution meteorites, have been named planetesimals, and hence the name of the hypothesis.

Now, while the whole is rotating and has the form of a spiral swarm, the tendency will be for the planetesimals to come together and form a series of nuclei in the arms, which, as they grow by accretion, become solidified and form the planets. In our present stage, most of them have been gathered in. A few are still falling as meteors, but the addition from this source to the size of the earth is quite insignificant.

This is the famous Planetesimal Theory. It explains the phenomena better than any other which has yet been suggested. But it may be that this, too, will eventually go the way of past theories, and its place taken by another newer one. It is too much to believe that we have now reached finality, and that our hypothesis outlines the actual physical facts of our earth's history.

Certain recent observations already suggest a somewhat different organization of the universe than that on which this theory is based. It has been pointed out by Campbell that while the gaseous nebulæ are to be found mainly in the direction of the Milky Way, the spiral nebulæ are never seen in these parts of the heavens but are numerous in directions at right angles. Now the stellar system is looked upon as being of a discoidal shape, and what we call the Milky Way is merely the direction of greatest depth and consequently of closest distribution of the stars. It follows that at right angles to this we look through the stellar system and out into infinite space, and it may be that the spiral nebulæ which are to be seen in these directions are not within our stellar system at all. Measurements of their motion towards and away from us indicate that they are moving at very rapid rates, probably as great as 500 miles per second, a very much greater speed than that of any known star. And yet, when their relative positions in space are compared with those they occupied fifteen years ago, scarcely any change can be observed. That is to say, the nebulæ are either all moving directly towards or away from the earth, which is incredible, or, although they have a lateral motion of enormous rapidity, they are so far away that the distance traveled in fifteen years is imperceptible to us. How great their distances may be we can not comprehend, even though it were expressed in figures. From here to the utmost confines of our stellar system is estimated as being of the order of 15,000 light years, that is the distance light will travel, going at the rate of 186,400 miles per second, in 15,000 years. And if this theory be correct, the nebulæ are so far away that, though as large probably as our stellar system, they seem to us scarcely larger than one of the planets. We may therefore look upon them as other stellar systems like our own. And if there be on a planet within one of these spirals, astron-

omers and telescopes such as we have, to them our stellar system would appear as a spiral nebula, a scarcely visible point of light in the starry heavens.

Now Campbell would carry us one step further in our search for the true theory for the origin of the world. At a certain point within the great spiral, a subsidiary whirl was developed within which grew, by the infall of planetesimals, as suggested by Chamberlin, our solar system, including the infinitesimal speck of matter upon which we live our unquiet lives.

VI

I have now traced the growth of man's idea of the origin of the planet on which he lives from the crude cosmogony of primitive ages up to the scientific theories of the twentieth century. Notwithstanding periods of intellectual stagnation and even of retrogression, this represents a continuous broadening of his grasp upon the realities of his physical environment. But we have not yet attained finality. The great mysteries of knowledge are as yet unfathomed.

But one thing we have learned.

> The spirit of eternal change,
> Which is the soul of nature

is all pervading. What we see is but an evanescent phase in an endless series of changes. There was a time when they did not exist; there will come a day when the thousands of fiery suns which we see in the heavens to-night will, each one, have cooled down to darkness and death. To our finite minds the life of a sun, measured as it must be by hundreds of millions of years, seems inconceivably long, but to "the spectator of all time and all existence" to borrow Plato's noble expression, it is but as a momentary flash. Now although it is believed that there are a great many dark bodies in the heavens, most of the stars are still alight. Together they came into being, together their fires will disappear.

> They shall all grow old as doth a garment, and as a vesture shalt Thou fold them up.

WILLIAM HARVEY MCNAIRN

WORK OF THE DEPARTMENT OF AGRICULTURE

REVIEWING the progress of the campaigns for increased production to meet war demands and conditions, David F. Houston, Secretary of Agriculture, in his annual report states that the farmers of the nation, patriotically responding to the appeals of agricultural and other agenices, have produced more than 5½ billion bushels of cereal food crops—exceeding by 1,000,000,000 bushels the five-year average for cereals—record crops of Irish potatoes and sweet potatoes, large crops of beans and sugar beets, and an unusually large crop of perishables. Authentic figures for meat, poultry, dairy products, and vegetable oils are not available for 1917, but rough estimates indicate that the quantity for the year is slightly greater than for either 1916 or 1915 and exceeds the five-year average by two or three billion pounds.

It must be borne in mind, however, the secretary says, that the 1917 cereal crops are 199 million bushels below the yield of 1915; that the carry-over of cereals from last year was much below the normal; that the percentage of soft corn of the 1917 crop—which can not be used for food—is unusually high; and that, with the destruction of live stock in Europe and the great demands from there for meats and fats, with consequent greatly increased exports from the country, the supply of meats and fats will not be adequate to meet the domestic needs and those of the nations with which we are cooperating.

"That the farmers of the nation have generously responded to the appeals for increased production, and that much has already been done to insure a large supply of foods and feedstuffs, justifies no let-down in their activities or in those of all agricultural agencies," the secretary says. "On the contrary, even greater efforts must be put forth in the coming

months if we are to meet satisfactorily the domestic demands and the needs of the nations with which we are associated in this struggle. There must be no breakdown on the farms, no failure of foods, feedstuffs, or clothing. I can not emphasize too strongly the urgent necessity of doing everything possible to bring about a still further increase in the production of all essential commodities, particularly of the staple crops and live stock.

The yields in 1917 of the major food crops are as follows, the secretary reports, according to unrevised estimates: 3,191,000,000 bushels of corn, 659,797,000 of wheat, 1,580,000,000 of oats, 201,659,000 of barley, 56,000,000 of rye, 16,813,000 of buckwheat, 33,256,000 of rice, 73,380,000 of kafir, 439,686,000 of Irish potatoes, 84,727,000 of sweet potatoes, 15,957,000 of commercial beans, 42,606,000 of peaches, 11,419,000 of pears, 177,733,000 of apples, and 7,621,000 tons of sugar beets.

"The actual increase in the acreage of crops sown this fall can not be accurately determined at this time," the secretary says. "There is every indication, however, that the farmers in the sections where fall grains can be profitably raised have patriotically responded to the nation's call for more breadstuffs. Reports made to the Bureau of Crop Estimates in August, before the campaign for increased acreages was well under way, indicated an intention on the part of farmers to increase their sowing of winter wheat by about 10 per cent., and of rye by about 3 per cent. If these intentions are realized, it will result in the planting of 44,100,000 acres of wheat and about 4,340,000 acres of rye. Reports received since August are to the effect that the fall-sown acreage of these two crops has been increased in nearly every state, although the drought in the Southwestern States and in portions of Washington has made it impracticable fully to carry out the planting program. The official estimate of the acreage of winter wheat and rye will be issued on December 19 after the planting of winter grains is completed in the South. Similarly, it is too early to determine the percentage of germination of seed actually sown, and therefore any prophecy at this time as to the actual harvest of winter wheat to be expected in 1918 would be merely a guess."

The report outlines the efforts of the department of agriculture to increase the meat supply and sums up the live-stock situation as follows:

"The number of milch cows and other cattle has shown an increase during the last four or five years, the estimate for the former for the present year being 23,906,000, as againts 22,768,000 a year ago and 20,497,000 in 1913, before the European war began, while that for the cattle is 43,291,000, as against 40,849,000 a year ago and 36,030,000 in 1913. Unfortunately, the number of sheep continues to decline; the estimate for 1917 is only 46,059,000, as against 48,483,000 a year ago and 51,482,000 in 1913. It is estimated that the number of hogs, which during recent years has shown an upward tendency, decreased over 4,000,000, or from 67,453,000 to 62,747,000. However, it is greater than it was at the beginning of the European war. The number of hogs varies from year to year more widely than that of the larger meat animals. . . . The mere statement that the population has steadily increased in this country—the gain in the 10 years from 1908 to 1917 being 13,000,000—with an absolute decrease in the live stock for the same period, would sufficiently emphasize the seriousness of the situation if conditions were normal and the demands for meats and fats were not so urgent." There is a close relationship, the report says, between the production of live stock and the supply of feedstuffs, and the large production of these necessaries during the present season should conduce to more satisfactory conditions for the producers of live stock.

Nation-wide campaigns to increase the meat supply are in progress, the report shows. As hogs and poultry yield the quickest returns, urgent efforts are being made to increase their production. Funds have been set aside from the appropriation made by the food production act to employ a force of 32 additional specialists to give their time to the task of increasing the number of hogs, 39 to encourage poultry raising, and 6 to assist producers of cattle.

By the end of October field agents of the department had assisted in the transfer of 100,000 cattle from localities where there is a shortage of feed to areas where feedstuffs are relatively abundant. This work has resulted in the saving to the nation of large numbers of animals.

Every effort has been and is being made to protect crops and live stock from diseases and pests. The force of experts dealing with these matters has been greatly increased and they are maintaining constant vigil and asissting in combating outbreaks in their early stages. Forty additional expert entomologists will be placed in the field to cooperate with the extension forces, and specialists familiar with seed treatment for the prevention of smuts of wheat, barley, oats, and rye, which alone cause losses of from 50 to 60 mlllion dollars a year, have been assigned to prevention work in Oregon, Ohio, New York, Tennessee, Indiana, Illinois, Oklahoma, Texas, Washington, and California.

Under the food production act, the facilities of the Bureau of Animal Industry for dealing with live-stock diseases have been further extended. Forty-six workers have been added to the force combating cattle ticks in the South. Fifty-one per cent. of the original infested territory has now been cleared of the tick. Hog cholera losses decreased 30 per cent. during the last year, and 65 additional veterinarians have been assigned to the work of controlling the disease. In 12 states an inspector has been detailed to assist in combating tuberculosis of cattle and swine and of abortion of cattle, and it is proposed to increase the number to 19. Other specialists are engaged in the work of controlling blackleg of cattle and anthrax of domestic animals.

Calling attention to the fact that the nation was facing an unsatisfactory situation with respect to its supply of foodstuffs and feedstuffs when the existence of a state of war was declared, the secretary outlines some of the efforts of the department and its cooperating agencies to increase the production of these commodities even before the entrance of the United States into the conflict. He then describes the steps taken to bring about more effective organization and closer coordination of the agricultural agencies of the nation, beginning with the conference with the official agricultural representatives of the various states, which was held at St. Louis, Mo., on April 9 and 10. States east of the Rocky Mountains were represented at the meeting and a similar conference for the states west of the Rockies was held at Berkeley, Cal., on April 13.

As an indication of the assistance which the bureaus of the department of agriculture have rendered and are rendering to the War and Navy Departments and to other branches of the government in connection with war problems, the annual report of the secretary of agriculture cites the following:

The Bureau of Animal Industry is cooperating in the reinspection of meats and meat food products at 27 naval stations and at various army camps, cantonments, forts, and other places. The dairy specialists of the department have investigated local situations and made suggestions to insure sanitary milk supplies for the army cantonments and naval stations and also have inspected large quantities of butter for the navy. Supplies of vegetables purchased and loaded on the naval supply ships are being inspected by representatives of the Bureau of Markets. The Office of Home Economics has studied the rationing question for the army, navy, and coast guard service. The Bureau of Chemistry has prepared specifications for army and navy foods and has analyzed products offered for inspection. This bureau also has assisted in standardization of army and navy food supplies and is conducting research investigations on the antiseptic qualities of some important compounds.

The Bureau of Entomology has placed its experts, as well as all information on camp sanitation in its possession, at the disposal of the Medical Corps. The Bureau of Soils has cooperated with the War Department in investigations relating to fixed nitrogen and sulphuric acid. Experts of the Office of Public Roads and Rural Engineering have been de-

tailed to assist the War Department in road building at the 16 cantonments.

The Forest Service has given assistance to the War and Navy Departments and to other national agencies in locating new sources of wood and in seasoning the product, has assisted in the organization of a regiment of engineers for forestry work abroad, and is now cooperating with the War Department in the organization of a second regiment. The Weather Bureau, in addition to furnishing weather information to the army and navy, has assisted the War Department in the organization of its aerological observation work and of a regiment for gas and flame service.

SCIENTIFIC EVENTS

AMAZON EXHIBITS AT THE UNIVERSITY OF PENNSYLVANIA MUSEUM[1]

There is now on public exhibition at the University of Pennsylvania Museum a large share of the collections which Dr. Wm. C. Farabee made during his three years' explorations of the Amazon, from which he returned last year. It has taken him a year to go over and catalogue his collections carefully, to label them and to install them in the galleries on the first floor of the museum.

During his three years in South America Dr. Farabee made his headquarters at Para, at the mouth of the Amazon, from which all of his various trips into the interior were made. The first journey was a thousand miles up the Amazon to Manaos, thence almost directly north into the highlands which divide Brazil from the Guianas, thence several hundred miles westward until it was no longer possible to travel by water, from which point he started eastward overland through the southern portion of British Guiana, spending many months among the Carib and Arowak, most of whom had never before seen a white man.

It was here that Dr. Farabee did some of his most important scientific work, since here were grouped a number of entirely distinct tribes of Indians, all of whom are rapidly diminishing in population and some of which are on the verge of extinguishment. From this point, having sent his collection down the Amazon, he made the terrible journey across the divide and down the Corentyne, during which he lost most of his equipment, all of his food and medicine, was obliged to live on monkeys and alligator meat, when even those were available, suffered terribly from fevers and finally reached the coast more dead than alive. Thence he went to the island of Barbados, where he met Colonel Roosevelt just returning from his trip through Brazil.

Dr. Farabee's second tour was up to the head waters of the Amazon River into the lower hills of the Andes in eastern Peru. Unfortunately, about the time he reached this section news of the great European war had come up the river and utterly dislocated all of his arrangements, making it impossible to get money or bring up supplies, so that he was obliged to return to Para, but not until after he had made some highly interesting and important researches and had secured a great number of the finest specimens of Conebo pottery in existence, which he managed to bring down with him and which are now on exhibition.

Subsequent trips were up some of the southern affluents of the Amazon, marching across from one great river to another, and investigating country never before trodden by a white man. Another series of explorations were to the north of the Amazon, not many hundred miles from the coast, where he also found hitherto unknown tribes and where he made collections, especially of large pottery animals used for burial urns. These were deep in the Amazon wood.

The results of all these journeyings are now on exhibition on the first floor of the museum. The room to the left is occupied with ancient and modern pottery and those whoever they were that made this pottery had a very much higher culture than any existing Indians in South America. It is doubtful if the Incas themselves at any time reached as fine a development in the making of pottery, but there is not the slightest clue as to who these people were, whence they came, when nor how they disappeared. None of the Indians who now occupy that portion of the country have even

[1] From *Old Penn.*

any myths about it, and this is the more remarkable because primitive races, as a rule, retain some shadowy recollection or myths of antecedent peoples for a great many centuries. Nowhere else in South America has there been the slightest trace discovered of a culture resembling this, or of several cultures, and it is very unfortunate that just now there does not seem to be any material at hand to solve the mystery. These colossal funeral jars are the most important features of this part of the exhibit. Some of them are large enough to admit two entire bodies seated side by side.

On the other side of the room in which this ancient pottery is shown Dr. Farabee has installed a great collection of several hundred pieces of the Conebo pottery. This is entirely modern and is the most striking pottery of the kind to be found anywhere in the world, and in fact only a few specimens of the smaller kind are to be found in any museum. About half a dozen of these jars are four feet high and about the same diameter, but resting on a very small base and having the general appearance of an inverted, truncated cone. They will hold several barrels each and are used by the natives to hold the beer, which they greatly enjoy.

THE CHEMICAL INDUSTRIES OF THE UNITED STATES

THE annual report of Franklin K. Lane, Secretary of the Interior, gives the data on the growth of the chemical industries in the United States since 1914. Not only have factories sprung up to manufacture products formerly imported but great expansion has taken place to supply the increased demand for all chemical products. The country now manufactures practically everything required along chemical lines.

The increase in capital invested in chemical industries was, in 1915, $65,565,000; in 1916, $99,244,000; and up to September, 1917, $65,861,000 over the preceding year. New chemical industries are now being opened up at an unprecedented rate, owing to war needs and the energy of American chemists and physicists.

Before the war 90 per cent. of the artificial colors and dyes were imported, five or six concerns with 400 operatives producing 3,300 short tons per year. Now there are over 90 enterprises, each making special colors, and 100 concerns making crudes and intermediates.

Sulphuric acid, the chemical barometer, has doubled in production. In 1916, 6,250,000 tons of 50° Bé. were produced. The estimate for 1917 is much greater, and the production for 1918 will again greatly increase.

By-product coking doubled its capacity in the last three years, yet in 1918 the United States will make half her coke in beehive ovens. Light oil, which contains the benzene and toluene needed for explosives, jumped from 7,500,000 gallons in 1914 to 60,000,000 gallons in 1917, and is again being largely increased. Ammonia production has increased 100 per cent. in three years and the visible supply is insufficient to meet demands.

Gasoline production has increased from 35,000,000 to 70,000,000 barrels per annum since 1914.

Potash importation from Germany was stopped by the war, which has stimulated production in this country. The production from January to June, 1917, was 14,023 short tons of potash. This is a small production, but sodium salts have been substituted for almost all purposes except agriculture. Shortage of labor and coal is seriously interfering with the potash-brine evaporation in Nebraska, which was yielding about 90 tons per day.

The production of explosives and consequent consumption of nitric acid has increased enormously. The nitric acid is still almost entirely made from Chili saltpeter, but synthetic nitrogen plants are under process of construction, and we have large quantities of coal-tar ammonia which can be used for munitions if necessary.

Before the war 40,000 tons of barite were imported from Germany for the manufacture of lithopone. Now five companies are producing this article from deposits in Tennessee, Kentucky, Virginia, and Missouri.

The smelting of all metals, iron, zinc, copper, antimony, tin, mercury, etc., and their

alloys has increased to meet the country's needs.

Domestic supplies of manganese and pyrite have been augmented.

These are but a few instances of our chemical progress. The matter can be summarized by saying that American chemists have met the country's needs as ably and completely as did the chemists of Germany. We can go forward with every confidence of no serious shortage of the many chemical products required for domestic consumption.

THE AMERICAN METRIC ASSOCIATION

THE association will meet in Pittsburgh on December 28 and 29 under the presidency of Dr. George F. Kunz, of New York. The first two sessions are to be held in conjunction with the Section on Social and Economic Science of the American Association for the Advancement of Science. The program will be as follows:

FRIDAY, DECEMBER 28

2 P.M. Mr. George W. Perkins, of New York, and Mr. J. W. McEachren, of the Crane Company, Chicago, will present papers for discussion.

Friday evening will be free for the opening session and reception of the American Association for the Advancement of Science, with which the American Metric Association is affiliated.

SATURDAY, DECEMBER 29

10 A.M. The officers will render their annual reports. These will be followed by Dr. William C. Wells, chief statistician of the Pan-American Union; Mr. Henry D. Hubbard, of the United States Bureau of Standards, and others dealing with the general problem of international standards and their application to important industries in the United States and Canada.

2 P.M. Dr. John A. Brashear, past president of the American Society of Mechanical Engineers, will introduce the speakers who have prepared papers for the Standards Committee of the American Metric Association. Engineers and business men are especially requested to attend this session. Technical problems in connection with the general use of metric weights and measures will be given special attention at this time.

6.30 P.M. An informal "Metric Dinner" will be served at the Hotel Schenley. The charge will be two dollars per cover, and those who desire to attend are asked to leave their names at the hotel office.

8 P.M. The final session in the Hotel Schenley, at which time officers for the ensuing year will be elected, and necessary business disposed of. The present rapid metric progress and the best methods for final success will be discussed by leaders in the metric movement.

SCIENTIFIC NOTES AND NEWS

THE secretary of agriculture has announced the appointment of Dr. John Robbins Mohler as chief of the Bureau of Animal Industry of the United States Department of Agriculture. Dr. Mohler succeeds the late Dr. Alonzo D. Melvin, who died on December 7. Dr. Mohler has been in the service of the Bureau of Animal Industry since 1897, and has been assistant chief of the bureau since July 1, 1914. During the long illness of Dr. Melvin, Dr. Mohler performed the duties of acting chief as well as those of chief pathologist.

A PORTRAIT of Professor Thomas C. Chamberlin, head of the department of geology and paleontology at the University of Chicago, has been presented to the university by graduates and former students of the department.

DR. LIGHTNER WITMER, professor of psychology in the University of Pennsylvania and director of the psychological laboratory and clinic, sailed last week for Europe. He expects to have the direction of social service work in a foreign country under a commissioner appointed by the War Council of the American Red Cross, and has been granted leave of absence by the university for the remainder of this year. During Dr. Witmer's absence, Dr. Edwin B. Twitmyer will be acting director of the psychological laboratory and clinic.

PROFESSOR ANTON JULIUS CARLSON, chairman of the department of physiology, at the University of Chicago, has been assigned to the Sanitary Corps of the United States Army and is expected soon to be in France.

ASSISTANT PROFESSOR FREDERICK E. BREITHUT, in charge of municipal chemistry in the department of chemistry in the College of the City of New York, has been appointed director of food conservation by the United States Government Food Commission, to cover the territory of Greater New York City.

DR. HUGO DIEMER, major in the ordnance department, U. S. R., is in charge of the Ordnance Inspection at Lowell, Mass., including accountability for all materials of United States property, production progress, shipping, and ballistic inspection.

ARTHUR H. NORTON, vice-president, and head of the department of mathematics of Elmira College, has been granted a leave of absence for the remainder of the year. He sailed for France on December 12 to take charge of a Young Mens' Christian Association base camp.

PROFESSOR ARTHUR W. BROWNE, of the department of chemistry of Cornell University, has been appointed chemical expert of the Ordnance Department. He will continue his work at Cornell University.

MR. RALPH MCBURNEY, instructor in the department of bacteriology of Oregon Agricultural College, has been commissioned as first lieutenant in the Sanitary Corps of the United States Army. According to orders he has reported at Letterman Hospital, San Francisco.

To Dr. Edwin F. Hirsch, of the department of pathology, of the University of Chicago, has been given leave of absence for service on the medical staff of the Officers' Reserve, United States Army.

DR. CHARLES W. STILES, of the United States Public Health Service, has been given jurisdiction over sanitary affairs in the zone about Camp Hancock, near Augusta, Ga., and will work in cooperation with the health forces already in operation there.

DR. GUSTAV F. RUEDIGER, for the last three and a half years director of the Hygienic Institute for LaSalle, Peru, and Oglesby, Illinois, has resigned that position to become director of the State Hygienic Laboratory of Nevada, University of Nevada, Reno.

PROFESSOR C. L. MCARTHUR, bacteriologist, University of Arkansas, has been appointed to be assistant bacteriologist in the department of bacteriology at Oregon Agricultural College.

THE council of the Institution of Civil Engineers of Great Britain has made the following awards for papers published in the proceedings without discussion during the session 1916–17: A Watt gold medal to Major H. S. B. Whitley (Neath); Telford premiums to W. C. Popplewell (Manchester), H. Carrington (Woodley, Stockport), Dr. A. A. Stoddard (Bournemouth), A. E. L. Chorlton (Lincoln), and B. M. Samuelson (Rangoon); the Manby premium to R. Bleazby (Perth, W.A.); the Webb prize to J. B. Ball (London), and the Howard Quinquennial prize to Dr. W. C. Unwin.

SECTION K of the American Association for the Advancement of Science has arranged for a symposium at Pittsburgh on the "Medical lessons of the war." Lieutenant George Loewy, of the French Army, is expected to give the principal paper.

THE third annual meeting of the Mathematical Association of America will be held at the University of Chicago on Thursday and Friday, December 27–28, 1917, in conjunction with the Chicago Section of the American Mathematical Society which meets on Friday and Saturday of the same week. The program reports of standing committees will be presented as follows:

1. Committee on Mathematical Requirements. "Scientific investigations of the committee," Professor A. R. Crathorne, University of Illinois. "The work of a committee representing the Central Association of Science and Mathematics Teachers," Mr. J. A. Foberg, Crane Junior College, Chicago.

2. Committee on Libraries. Discussion opened by Professor H. E. Slaught, University of Chicago.

3. Committee on Mathematical Dictionary. Preliminary report by the chairman, Professor E. R. Hedrick, University of Missouri.

At a meeting of the teachers of physics in Indiana colleges held at Bloomington, Indiana, on December 10, steps were taken toward an organization of the physics research work throughout the state. Dr. A. L. Foley, head of the physics department of the University of Indiana and chairman of the Scientific Research Committee of the State Council of Defense, was chosen as director of this movement. It is hoped that this organization will survive the war period and prove a valuable aid in developing research work in physical science in Indiana.

Professor George Sarton, lecturer on philosophy at Harvard University and editor of *Isis*, gave at the University of Chicago a public lecture, with illustrations, on December 7, his subject being "Science and civilization at the time of Leonardo da Vinci."

Dr. William Curtis Farabee, curator of the American section of the University of Pennsylvania Museum, lectured on "Exploration in the valley of the Amazon," before the Geographic Society of Chicago on December 14.

Richard Swan Lull, professor of vertebrate paleontology at Yale University, gave an illustrated lecture on the Luther Lafflin Kellogg Foundation, under the auspices of the Phi Beta Kappa Society at Rutgers College, on December 7. His subject was "The pulse of life."

The governors of the West Ham Municipal Central Secondary School, London, plan to call the institution "The Lister School," to perpetuate the association of Lord Lister with the borough.

The death is announced at the age of fifty-seven years of Dr. Ramon Guitaras for many years professor of surgery in the New York Post Graduate Hospital.

William McKnight Ritter, the astronomer, formerly connected with the Nautical Almanac Office and there closely associated with the work of George W. Hill, died on November 6, at his home in Pottsgrove, Pa., at the age of seventy-one. In his earlier astronomical career he became, through Professor Watson, of Ann Arbor, greatly interested in the computation of orbits for minor planets, and during the later years he devoted special study to the problem of the general perturbations of these planets.

Dr. Ami Jacques Magnin, chief surgeon of the American hospital at Neuilly, died suddenly on November 25.

Dr. J. Peyrot, professor of surgery at the University of Paris and senator, has died at the age of seventy-four years.

F. C. Barraza, professor of organic chemistry at the University of Buenos Aires, has died, aged fifty-five years.

We learn from *Nature* that the death is announced, while leading his platoon during one of the recent advances in France, of Second Lieutenant F. Entwistle, second assistant at the Observatory, Cambridge, aged twenty-one years. Mr. Hartley, first assistant at the Cambridge Observatory, was killed on the *Vanguard* on July 9. The double tragedy exhausts the staff of the observatory, as distinct from the Solar Physics Observatory, except for the director.

In view of the many unusual conditions due to the war, it has been deemed inadvisable to hold a meeting of the Association of American Geographers this year, and the meeting planned for Chicago has been abandoned. Professor Robert DeC. Ward's presidential address, entitled "Meteorology and aviation: some practical suggestions," will be published in the near future. This, and other papers prepared for the meeting, will appear in the *Annals* for 1918.

After serious consideration and correspondence with all exhibitors, the managers of the Chemical Exposition have decided to abandon plans to hold a Chemical Exposition in Chicago in the Spring. This action was taken because of insufficient support secured to make

a large and representative exposition, all the exhibitors wishing to confine their efforts toward making the Fourth National Exposition of Chemical Industries in New York, week of September 23, 1918, the greatest event in the history of American Chemical Industry.

THE directors of the Fenger Memorial Fund announce that the sum of $500 has been set aside for medical investigation, the money to be used to pay a worker, the work to be done under direction in an established institution, which will furnish the necessary facilities and supplies free. It is desirable that the work should have a direct clinical bearing. Applications with full particulars should be addressed to Dr. L. Hektoen, 637 S. Wood St., Chicago, before January 15, 1918.

A NATIONAL institute of malariology is about to be established in Italy; it will be a part of the department of agriculture. Its objects are to investigate the relations between malaria and agriculture; to study experimentally and otherwise the direct and indirect causes of the unhealthiness of malarial districts; and to organize and direct a campaign against those causes, and particularly against the *Anopheles*.

MR. HODGE, British minister of pensions, received on September 17, a private deputation from the Roehampton Hospital Committee regarding the proposal to establish a national experimental laboratory for the purpose of designing and controlling the manufacture of artificial limbs for disabled soldiers. By experiments, and by making full use of the experience of men who had been fitted with artificial limbs, it was hoped, the deputation suggested, to improve greatly the types of limbs supplied at present. Mr. Hodge declared his intention of taking immediate steps to seek the necessary funds for the establishment of a National Experimental Laboratory which might ultimately become a national factory for manufacturing limbs. For the present, however, he was opposed to the establishment of a national factory. It was, in his view, essential that the committee of management of the National Laboratory should be small, representative of surgeons and mechanical experts, and distinct from any committee managing hospitals for limbless men. The laboratory committee would be directly responsible to the Ministry of Pensions, and would be empowered to ensure that the improvements which they recommended should at once be introduced into the manufacture of artificial limbs.

IT was proposed to submit a plan for establishing a central organization of engineers and educationists to a conference of engineers from all parts of the country which was held at the British Institution of Civil Engineers on October 25. Sir Maurice Fitzmaurice, president of the institution, presided and the honorary organizers of the movement are Mr. A. P. M. Fleming (British Westinghouse Company, Trafford Park, Manchester) and Mr. A. E. Berriman (chief engineer, Daimler Company, Coventry). The plan suggested, which includes the reinstatement of the best ideals of the old system of apprenticeship, provides for the setting up by engineering firms of a central bureau for the better coordination of engineering training and the appointment of a representative committee of engineering and educational interests to initiate action.

UNIVERSITY AND EDUCATIONAL NEWS

A GENERAL Science Hall, erected at a cost of $60,000, is under construction at Defiance College, Defiance, Ohio. It will be a three story building and is expected to be completed by next July.

THE Provost Marshal General has sent the following telegram to the governors of all states:

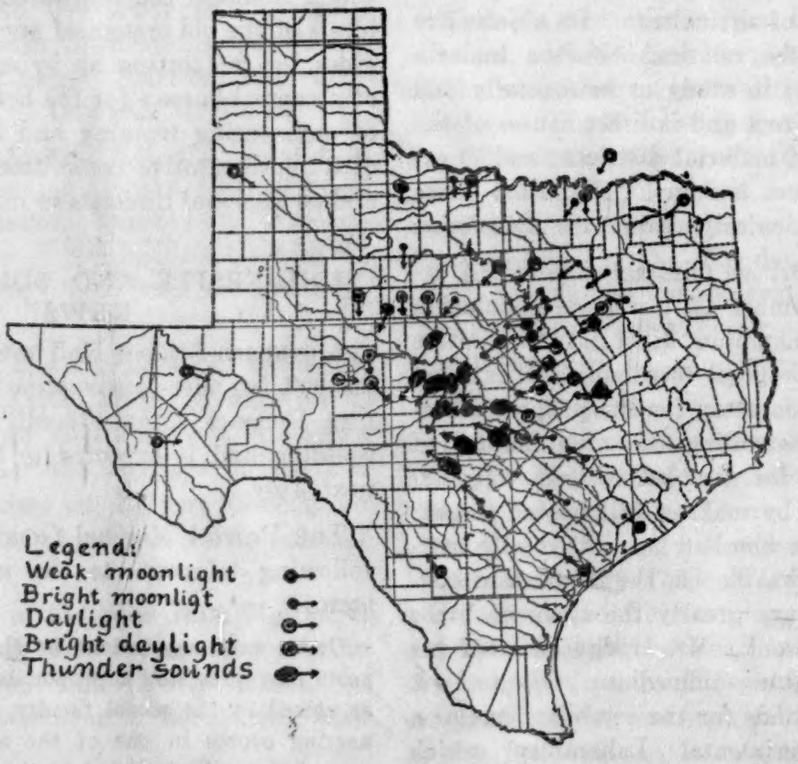
Under such regulations as the Chief of Engineers may prescribe a proportion of the students, as named by the school faculty, pursuing an engineering course in one of the approved technical engineering schools listed in the War Department, may enlist in the Enlisted Reserve Corps of the Engineer Department and thereafter, upon presentation by the registrant to his local board of a certificate of enlistment, such certificate shall be filed with the Questionnaire and the registrant shall be placed in Class 5 on the ground that he is in the military service of the United States.

Dr. Charles T. P. Fennel, for fifteen years state chemist in Ohio, and later professor of chemistry in the Cincinnati College of Pharmacy, has been appointed to the chair of materia medica at the University of Cincinnati to fill the vacancy created by the death of Dr. Julius Eichberg.

DISCUSSION AND CORRESPONDENCE

A TEXAS METEOR

On October 1, at about 10:30 P. M., an unusually bright meteor appeared over the central part of Texas. The undersigned promptly made arrangements to secure information on its appearance throughout the state, while the phenomenon was yet fresh in the memories of those who saw it. Notes from some threescore observers have been secured. From these it appears that the place where this aerolite fell must be somewhere in or near Kimble County. The observed directions all converge toward this county. Evidently the path this meteor followed was at a considerable angle to the horizon and had a course from northeast to southwest. Nearly all observers agree that at first the light of this meteor was small. Increasing rapidly in brilliancy, it terminated abruptly with an explosion at some considerable distance above the ground. To the most distant observers it appeared to reach the horizon. Over an area of some 150 miles in diameter, north of Bandera County, sounds like that of thunder were heard from three to five minutes after the meteor disappeared. At Brady and at one or two other places, these sounds are reported to have been strong enough to shake buildings and to cause dishes and windows to rattle. The light in the same region is likened to strong lightning and it is said to have been blinding to some observers. The usual thin cloud of dust high in the sky was noted by several parties, who say it could be distinctly seen for 40 minutes after the fall.



The meteor was observed over the entire state, from the Gulf to the Panhandle and from the northeast counties to the far mountains west of the Pecos, a distance of nearly six hundred miles. Several parties who saw the bright body at a distance of about 200 miles or less, report hearing a swishing or

buzzing sound, which seems to have been simultaneous with the appearance of the light. This communication is prompted chiefly by a desire to learn if such sounds have been previously reported as being connected with meteoric falls. Several circumstances in the present case indicate that this sound was real, and not psychological. May it have been the indirect result of some form of electric energy? One observer seems to refer this sound to objects attached to the ground.

J. A. UDDEN

AUSTIN, TEXAS,
October 22, 1917

ON THE COLLOID CHEMISTRY OF FEHLING'S TEST

TO THE EDITOR OF SCIENCE: Fischer and Hooker make the following statement in their article "On the Colloid Chemistry of Fehling's Test," page 507, SCIENCE:

> Formaldehyde reduces Fehling's solution not only to the ordinary cuprous oxide, but to the metallic copper. The copper comes down in colloid form, but as this happens, a second reaction ensues in which the metallic copper acts upon the formaldehyde and decomposes it with the liberation of hydrogen. The liberation of hydrogen continues for hours, until either all the formaldehyde has been decomposed or all the copper salt has been reduced.

In a study on the preparation of colloidal gold solutions by Dr. J. H. Black and myself (which is being reported by Dr. Black at the present meeting of the A. M. A. at New York), question arose regarding the probable explanation of the mechanism by which neutral sols are obtained although distinctly alkaline (to alizarine) sols should result from the proportions of reagents employed. I suggested the hypothesis that the colloidal gold acted as a catalytic agent to oxidize the free formaldehyde to formic acid, which latter reacted with the potassium carbonate responsible for the alkalinity.

It occurs to me therefore that it would be better to picture the colloidal copper functioning as a catalytic agent which oxidizes the HCHO in part, the remaining part serving to reduce the copper salt. The idea advanced by them that colloidal copper is produced is certainly reasonable; it is very difficult to understand how formaldehyde would liberate hydrogen.

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SCIENTIFIC BOOKS

The Fundamentals of Botany. By C. S. GAGER. Philadelphia, P. Blakiston's Sons & Co.

We are fortunate in the United States in having a number of excellent elementary botanical text-books, written from different points of view. Professor Coulter has furnished an admirable beginners' book conceived from the standpoint of the head of a botanical department in a large university, who is at the same time an educational expert. From the hands of Mr. Bergen, whose recent demise we all deplore, we have had a succession of well-approved texts, written by one thoroughly in touch with instruction in the secondary schools. Professor Ganong has put forward from time to time books which reflect the outlook of the teacher in college work. The present volume comes from one who is the director of one of the most important botanic gardens in the country and who has, at the same time, made it his business to get into touch with his community, primary and secondary schools as well as the general public, in the closest possible manner. There can be little doubt, particularly at the present juncture, when the general public under the spur of patriotism and necessity, has largely abandoned its usual attitude of indifference toward plants, that Dr. Gager's book will prove extremely useful.

The relation of the author to his subject is admirable, as is shown by the following citation (p. 192).

> . . . In fact, we may say that our ignorance of life-processes greatly exceeds our knowledge. Very much more remains to be ascertained than has already been found out; for example, what is protoplasm? Nobody really knows. We have analyzed the substance chemically, we have carefully examined and tried (but without complete

success) to describe its structure. We know it is more than merely a chemical compound. It is a historical substance. A watch, as such, is not. The metal and parts of which a watch is made, have, it is true, a past history; but the watch comes from the hands of its maker *de novo*, without any past history *as a watch*. But not so the plant cell. It has an ancestry *as a cell;* its protoplasm has what we may call a physiological memory of the past. It is what it is, not merely because of its present condition, but because its ancestral cells have had certain experiences. We can never understand a plant protoplast merely by studying it; we must know something of its genealogy and its past history.

It will be noted that although a physiologist in outlook, he has properly emphasized the historical and structural point of view so often and so deplorably neglected by the cultivators of disembodied plant physiology. The author obviously considers that living matter is to be studied *in vita* rather than *in vitro* (whether in glass models or merely in chemical glassware). By his broad outlook he has avoided the narrows which lead, on the one hand, into the ancient Scylla of systematic botany, or, on the other, into the more modern Charybdis of plant physiology.

The book is admirably printed on thin paper, so that its more than six hundred pages and well over four hundred illustrations make a conveniently thin and flexible volume, which is rendered still more useful by soft covers and rounded corners. The illustrations, whether original or borrowed, are for the most part good, and in some instances are of striking excellence. An adequate amount of space is given to the important themes of genetics and evolution, while the historical side is not neglected. Dr. Gager's work should be in the hands of every teacher of botanical science, and by its broadness and balance is admirably adapted for use in schools where the one-sided teaching of the facts of botany is by necessity and common sense excluded. The general text is accompanied by a laboratory guide, which is ingeniously contrived to avoid repetition and equally emphasizes structure and function.

E. C. Jeffrey

SPECIAL ARTICLES

WHY CHLOROFORM IS A MORE POWERFUL AND DANGEROUS ANESTHETIC THAN ETHER

Any one accustomed to administering anesthetics has observed that the amount of chloroform necessary to produce deep narcosis is less than that of ether; also that the period between slight and deep anesthesia is shorter and the lethal dose smaller with chloroform than with ether. These differences in the effects of ether and chloroform led Hewitt to state in his book on "Anesthetics" that chloroform is seven or eight times more powerful as an anesthetic than ether. In chloroform poisoning it is known that many of the organs, particularly the liver, are very seriously injured, while it is more difficult, or impossible in many instances, to produce such injuries with ether.

It is now recognized that in both chloroform and ether anesthesia oxidation is decreased or rendered defective, as is indicated by the decreased oxygen intake and carbon dioxide output and the appearance of certain incompletely oxidized substances such as β-oxybutyric and diacetic acids, and acetone. The decreased oxidation in anesthesia with resulting acidosis is much more likely to occur and to a much greater extent with chloroform than with ether.

Using practically all the means by which it is known that oxidation can be increased in an animal, as, for example, by food, by increasing the amount of work, by fight, or by thyroid feeding, we have found that there is always an accompanying increase in catalase, an enzyme in the tissues which possesses the property of liberating oxygen from hydrogen peroxide. We have also decreased, or rendered defective, the oxidative processes in animals, as, for example, by decreasing the amount of work, by starvation, by phosphorus poisoning, or by extirpation of the pancreas, thus producing diabetes, and have found that there is always a corresponding decrease in catalase. From these results it was concluded that it is probable that catalase is the enzyme in the body principally responsible for oxidation.

The object of the present investigation was to determine if catalase is decreased more quickly and more extensively during chloroform anesthesia than during ether anesthesia parallel with the greater decrease in oxidation and the quicker and more powerful action of chloroform. Cats were used in the experiments. The anesthetics were administered by bubbling air through ether or chloroform in a bottle which was connected by a rubber tube to a cone adjusted to the snout of the animal. The catalase content of the blood, taken from the external jugular vein, was determined before the administration of the anesthetic and at intervals of 15 minutes during the administration. The determinations were made by adding 0.5 c.c. of blood to 250 c.c. of hydrogen peroxide in a bottle at 22° C. and as the oxygen gas was liberated it was conducted through a rubber tube to an inverted graduated cylinder previously filled with water. After the volume of gas thus collected in ten minutes had been reduced to standard atmospheric pressure, after resulting volume was taken as a measure of the amount of catalase in the 0.5 c.c. of blood. The bottles were shaken in a shaking machine during the determinations at a rate of about 180 double shakes per minute.

The average amount of oxygen liberated by the blood of three cats previous to the administration of ether was 812 c.c.; that liberated after the animals had been under ether for 15 minutes was 740 cc.; that after 30 minutes of ether anesthesia, 630 cc.; that after 45 minutes, 475 cc.; that after 60 minutes, 480 cc.; after 75 minutes, 400 cc.; and that after 90 minutes, 380 cc. It will be seen that the catalase of the blood was gradually decreased during the 90 minutes of ether anesthesia, as is indicated by the gradual decrease in the amount of oxygen liberated, and that at the end of 90 minutes the catalase had been decreased by about 54 per cent., as is indicated by the decrease in the amount of oxygen liberated from 812 cc. to 380 cc.

Similarly determinations were made of the catalase of the blood of cats previous to chloroform anesthesia and at intervals of 15 minutes during the anesthesia. The average amount of oxygen liberated by the blood of three cats previous to the administration of chloroform was 900 c.c; that liberated after the animals had been under chloroform anesthesia for 15 minutes was 525 c.c.; that after 30 minutes, 325 c.c.; that after 45 minutes, 334 c.c.; that after 60 minutes, 320 c.c.; after 75 minutes, 330 c.c.; and that after 90 minutes, 310 c.c. It will be seen that the chloroform produces a very abrupt decrease in the catalase of the blood during the first fifteen minutes of the administration as is indicated by the decrease in the amount of oxygen liberated from 900 to 525 c.c., and that at the end of 90 minutes the catalase had been decreased by about 65 per cent., as is indicated by the decrease in the amount of oxygen liberated from 900 to 310 c.c.

By comparing the decrease in the catalase produced by ether and by chloroform it will be seen that the ether produced a gradual decrease as is indicated by the gradual decrease in the amount of oxygen liberated by 0.5 c.c. of the different samples of blood from hydrogen peroxide, whereas chloroform produced a very abrupt decrease during the first fifteen minutes of narcosis as is indicated by the great decrease in the amount of oxygen liberated from 900 to 325 c. c.

We have shown that small amounts of chloroform or ether added to blood in vitro destroy the catalase of the blood very rapidly. We have also shown that the liver is the organ in which catalase is formed, given off to the blood carried to the tissues.

The explanation that suggests itself for the decrease in the catalase of the blood produced during chloroform and ether anesthesia is the direct destruction of the catalase of the blood by the anesthetic and the decrease output of the catalase from the liver brought about by injury of the liver by the anesthetic. The more powerful and dangerous effect of chloroform as an anesthetic is attributed to the fact that chloroform is more potent than ether in producing a decrease in catalase, both by direct destruction of the catalase of the blood and by injuring the liver, thus decreasing the

output of catalase from this organ with resulting decrease in oxidation. In fact it is probable that the cause of anesthesia is to be found in the decrease in the oxidative processes particularly of the nervous system produced presumably by the destruction of the catalase by the anesthetic. The specific action of anesthetics on the nervous system, according to this hypothesis, is due to the greater solubility of the lipoids or fat-like substances of nervous tissue which facilitates the entrance of the narcotic into the nerve cell and thus exposes the contained catalase more directly to the destructive action of the drug.

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THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

The formal organization meeting of the American Association of Variable Star Observers was held at the Harvard College Observatory, Cambridge, Mass., on November 10th and was attended by 25 or more members, almost all of whom are active participants in the observation of variable stars. The meeting was called to order by Wm. Tyler Olcott, who for the past six years has acted as secretary of the informal association, and A. B. Burbeck was appointed temporary chairman. A carefully drawn up constitution was read and accepted and then the officers and council members of the association were duly elected. D. B. Pickering, of East Orange, N. J., was elected president; H. C. Bancroft, Jr., of West Collingswood, N. J., vice-president; W. T. Olcott, of Norwich, Conn., secretary, and A. B. Burbeck, of North Abington, Mass., treasurer. The four members of the council are Professor Anne S. Young, of Mt. Holyoke College Observatory, J. J. Crane, of Sandwich, Mass., for two years, and Miss H. M. Swartz, of South Norwalk, Conn., and C. Y. McAteer, of Pittsburgh, Pa., for one year.

While waiting for the result of the election to be announced by the tellers, a general discussion of the most suitable size of telescope for the use of the observers was opened up, and later, a discussion of plans for the most systematic observation of the 300 or more variable stars under research was also freely indulged in.

In taking the chair as the first president of the association, Mr. Pickering reviewed, in a few words, the past achievements of the Variable Star Observers, and mentioned their aims for the future.

Tea was kindly served by the director of the observatory in the afternoon, and then lantern slide exhibits were given, one by Miss A. J. Cannon, showing some of the celestial wonders as revealed in the photographic telescopes, and another by Mr. Leon Campbell, illustrating the progress of the study of the star SS Cygni and what attempts are being made to fathom its seemingly irregular variations, both in light and period.

While an inspection of the work of the observatory was being made, the more experienced members observed this same SS Cygni in the comfortable 12-inch Polar Telescope, all under like conditions, and the result of the estimates of the 17 observers was that the star was then of the magnitude 11.21, with a probable error of 0.12 magnitude.

At a short meeting of the council, three noted variable star observers were elected to honorary membership, Professor E. C. Pickering, director of the Harvard Observatory; Rev. J. G. Hagen, director of the Vatican Observatory, Rome, and Professor J. A. Parkhurst, of the Yerkes Observatory. Professor Pickering was also elected as the first patron of the association.

The council also elected nine members to life membership and the total membership therefore numbers 84, of which 72 are active; 9, life, and 3 are honorary members, with 1 patron.

A sumptuous banquet was served in Boston that evening at which 20 members and four guests were present. Interesting after dinner speeches were made by Professors Pickering and Bailey, and Miss Cannon and Mr. Olcott, Mr. Campbell acting as toastmaster.

The meeting was considered the climax of all those yet held and marks the successful launching of a full-fledged association in America for the regular observation of variable stars by a group of amateur and professional astronomers, which has been doing excellent work along this line for some years past, and which bids fair to be even more useful to science in the near future.

Several committees were appointed by the president to consider the matter of telescopes, charts and schemes of work, and it was voted by the council to hold the spring meeting at East Orange, N. J., on May 6, 1918, at the invitation of President Pickering.

For those members who remained in Boston until the next day, an excursion was arranged to

visit the Blue Hill Meteorological Observatory, where Professor McAdie was most attentive and explained in detail the investigations he is carrying on there.

The opportunity for interested parties to enroll themselves as charter members remains open until December 31, 1917, and all such persons are invited to join the association, to whom copies of the constitution will be sent upon application to the secretary, Wm. Tyler Olcott, 62 Church Street, Norwich, Conn. L. C.

BOSTON MEETING OF THE AMERICAN CHEMICAL SOCIETY. IV

DIVISION OF PHYSICAL AND INORGANIC CHEMISTRY

H. P. Talbot, *Chairman*

E. B. Millard, *Secretary*

Joint Meeting with Division of Organic Chemistry, Wednesday Morning

1. *Two new laboratory instruments:* ARTHUR JOHN HOPKINS.

(*a*) A buret-micrometer.

A reading device which permits of correct readings to .001 c.c.

(*b*) A balance for first-year students.

A three-arm balance with non-removable riders in a glass and aluminum case. A distinctive arrest. The bearings are of stellite and the arms of invar tape. The ratio of the arms is such that the weight used is to the load as 4: 1.

2. *Water-lag in a buret:* ARTHUR JOHN HOPKINS.

A study of the amount of pure water clinging to the sides of a buret, under different speeds of discharge. The rule is deduced that, in order that comparable readings may be obtained, the discharge should not be faster than 12 to 15 seconds per cubic centimeter.

Limits of individuality in chemistry: N. T. BACON. The chances for variation become less and less as complexity of structure is reduced, but now that we recognize atoms as being composed of many parts is it not proper to recognize that at least the individual molecule, if not the atom itself, may have an individuality? Probably each atom would have a normal arrangement of the multiplicity of parts going to build up the atom, but the question is raised whether it is not probable that owing to imperfect elasticity these frequently stand out of the normal position with reference to each other and reducing their tendency to combine so that frequently many times as many collisions are necessary before completion of combination as would be called for by theory.

A new hydrate of lime: H. W. CHARLTON. This hydrate of lime possesses marked plasticity, and differs from the ordinary $CaO \cdot H_2O$ in containing a considerably less amount of water. Its method of formation precludes the possibility of its being a mixture of CaO and $CaO \cdot H_2O$. One example of its formation comprises digesting $CaO \cdot H_2O$ with ten times its weight of water at 225 pounds pressure for a couple of hours. The resulting plastic material contains but slightly more than 15 per cent. water of combination while it originally contained over 24 per cent. and its specific gravity is but 1.95, while that of $CaO \cdot H_2O$ is about 2.078. This is remarkable as it would naturally be supposed that the specific gravity would lie some place between that of CaO.–3.25 and that of CaO.–2.078.

An investigation of the reaction between antimony and the solutions of sodium in liquid ammonia: EDWARD B. PECK. Solutions of sodium in liquid ammonia of concentrations from 0.0049 to 1.2482 gm. atoms of sodium per liter of liquid ammonia were sealed in glass bombs with an excess of antimony and allowed to react at room temperature for from two months to a year. A dark-brown, slightly soluble compound first formed, after which a dark-red solution appeared and the precipitate dissolved. The ratio of antimony to sodium in the solution does not correspond to a small integral number and changed with the concentration of sodium. The ratio Sb/Na changed very rapidly in dilute solutions from a value of $Sb/Na = 1.98$ to a maximum of $Sb/Na = 2.333$ at a sodium concentration of about 0.4N, after which there was a slight decrease to a value of $Sb/Na = 2.254$ at a concentration of 1.248. Two plots of the results were shown, one the ratio Sb/Na against the concentration of sodium, and another the log. of the sodium concentration against the ratio Sb/Na. In both these plots the results lay on a smooth curve. The apparatus for carrying out this work was described in detail. Weighed amounts of sodium were put up in small glass capsules. These capsules were placed across a tube provided with an electromagnetic hammer in the inside, which could be actuated by a solenoid outside. The reaction tube containing metallic antimony was sealed on to this tube. The tube was also connected to a supply of pure ammonia and to a vacuum pump. After evacuating the apparatus, ammonia was condensed in the reaction tube by surrounding it with a bath of liquid ammonia. The sodium was

then introduced into the solution by breaking the capsule in two with the electro-magnetic hammer. As soon as the reaction was well started, the bomb was sealed off and allowed to react at room temperature. The bomb consisted of two compartments. When the reaction was completed, the solution was poured off from the excess antimony, and the antimony washed by distilling the solvent over from the solution. The analysis was completed by distilling off the solvent into weighed water bottles and weighing the antimony left behind. Electrolyses of these solutions were carried out at the temperature of boiling ammonia. The electrolyses showed that the compounds in solution are electrolytic in nature and that more than one atom of antimony is associated with each negative carrier. Both the analyses and electrolyses showed that there are at least two compounds involved in the final equilibria, one having more than two atoms and one having less than two atoms of antimony for each negative charge. These compounds are in some ways similar to the polyiodides. A detailed exposition of this investigation will be offered for publication to the *Journal of the American Chemical Society*.

The effect of acid concentration on the photochemical oxidation of quinine by chromic acid: G. S. Forbes and R. S. Dean. In a previous investigation of this reaction by Luther and Forbes, the acid concentration had been constant. In the dark, with concentrations of CrO_3 and purified quinine constant, the velocity varies as the square of the acid concentration. A shallow cylindrical dish was bisected by a glass partition, and revolved under a quartz mercury lamp. Provisions were made for stirring, cooling and temperature measurement. Solutions as described above were compared in pairs. After correction had been made for the dark reaction, the velocity of the photochemical reaction was found independent of acid concentration. It was also proved that quinine solution exposed to light does not retain its activation for long in the dark.

The temperature coefficient of the distribution ratio: G. S. Forbes and A. S. Coolidge. Solubilities in two and three component systems involving water, ether and succinic acid were determined or redetermined at 15°, 20° and 25°, also the distribution ratio of the succinic acid between two ether-water phases. An equation was derived and verified showing the temperature coefficient of the distribution ratio, with excess of the acid, as a function of the temperature and mutual solubility coefficients of each substance in each layer. The distribution ratio, when calculated on the basis of ether-water phases in which the ratios ether to water are constant, is by no means independent of the concentration of succinic acid. Evidence was secured that the average degree of association of water dissolved in ether at these temperatures is somewhat less than two.

The application of palladium as an indicator for silver titrations: L. Schneider. A very dilute solution of palladous nitrate, dissolved in an excess of nitric acid, is added to the silver nitrate solution which is then titrated with potassium iodide. The silver nitrate is precipitated by the potassium iodide and the least excess of potassium iodide is converted by the palladous nitrate to palladous iodide which is visible to the extent of one part in a million. For very dilute solutions, this method gives better precision than the Volhard method. The size of the plus and minus errors have been determined. The constant plus error in concentrated solutions is due to the palladous iodide being carried down by the silver iodide at the end-point, whereas the negative error is caused by the absorption of silver nitrate by silver iodide. The standard method for overcoming these errors has been applied with such effect that not only good precision but satisfactory accuracy has been obtained. The ease and rapidity with which the standard solution and the indicator can be prepared recommend this new method. Also the palladous nitrate method can be used to better advantage than Volhard's in cases where the silver nitrate solutions are colored pink or yellow. Nitrous acid interferes and must be boiled off before titrating.

The application of the thermodynamic methods of Gibbs to equilibria in the ternary system H_2O-K_2SiO_3-SiO_2: George W. Morey and Erskine D. Williamson. A discussion of Gibbs's derivation of the phase rule and the application of Gibbs's thermodynamic methods to various types of heterogeneous equilibria occurring in the ternary system H_2O-K_2SiO_3-SiO_2. The slopes of the various P-T curves which proceed from a quintuple point are discussed, with special reference to the dependence of the slope of a given curve on the composition of the phases which coexist along it. The change in slope with change in composition of phases of variable composition is discussed in detail. Conclusions reached in the above discussions are applied to typical cases in the ternary system H_2O-K_2SiO_3-SiO_2.

(*To be continued*)